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Evaluating workplace safety in the oil and gas industry during the COVID-19 pandemic using occupational health and safety Vulnerability Measure and partial least square Structural Equation Modelling

Joshua Guzman [a], Gwen Arianne Recoco [a], Al Wahid Pandi [a], Jerico M. Padrones [a,b], Jonathan Jared Ignacio [a,*]

[a] Department of Petroleum Engineering, College of Engineering, Architecture and Technology, Palawan State University-Main Campus, Tiniguiban Heights, Tiniguiban, Puerto Princesa City, 5300, Palawan, Philippines

[b] Department of Mathematics, College of Science, Palawan State University-Main Campus, Tiniguiban Heights, Tiniguiban, Puerto Princesa City, 5300 Palawan, Philippines, 5300, Palawan, Philippines

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ABSTRACT

The study aims to apply the Partial Least Squares Structural Equation Modeling (PLS-SEM) to model workplace safety in the Oil and Gas Industry (OGI) during the COVID-19 pandemic. The five areas of the Occupational Health and Safety (OHS) Vulnerability Measure (e.g., Exposure to Workplace Hazards, Policies and Procedures in the Workplace, Perception on Health & Safety Culture in the Workplace, Self-Awareness in Health & Safety Procedures and Responsibilities, and Preventive Measure for Prevention of the Transmission of COVID-19 at Workplace) were considered as the constructs to be evaluated. Fifty workers from the oil and gas industry worldwide participated in the online survey, and the data were analyzed using the SmartPLS software. The results revealed that only Perception on Health & Safety Culture was a significant factor influencing the perceived workplace safety in the OGI during the COVID-19 pandemic ($\beta = 0.603$; t-value $= 3.323$; p-value $=$ 0.001). The study suggested that the oil and gas companies should maintain a positive perception of health and safety culture to improve workplace safety even during the pandemic.

1. Introduction

With the COVID-19 pandemic, every country faces an unprecedented, massive worker safety crisis (Phillips et al., 2020). Occupational injury, illness, and workplace fatalities are significant public health concerns (Lay et al., 2016), especially in critically hazardous industries like oil and gas, even amid the pandemic. Practicing COVID-19-related health and safety protocols such as social distancing has become an integral part of promoting cleaner environmental systems in almost any company worldwide. Without it, workers are at risk of acquiring the virus. As a result, it threatens the availability of a workforce that is supposed to improve the operations yield and environmental management strategies. However, it is challenging on offshore oil platforms because of the restricted and limited work area or space. Some companies may initially opt to enact preventive measures such as sending workers home to avoid further widespread of the virus, affecting the companies' performance (Campbell, 2020).

In April 2020, the first quarter of the COVID-19 pandemic, the virus had already infected workers from several oil rigs in the Gulf of Mexico (Hamel, 2020). In July of the same year, a state-owned oil producer in Mexico was severely affected by the COVID-19, with 202 employees and five contractors dead from the virus. No other company had reported fatalities that come anywhere near that number (Stillman, 2020). The fatality rate for oil and gas employees was seven times higher than in other industries.

Blunt et al. (2020) claimed that the oil and gas activities, mostly excused from the lockdown measures, are considered crucial activities by governments. However, the continued operations would likely become challenging due to workforce shortages as employees become infected by the virus and the practical difficulties in many cases of social distancing (Blunt et al., 2020).

In South Korea, a recent study conducted by Lee and Kim (2021) had found out that occupational groups were at high risk of COVID-19. The authors identified the number of such workers and examined the

* Corresponding author.
E-mail address: jignacio@psu.palawan.edu.ph (J.J. Ignacio).

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prevalence of protective resources by employment status. The result of the study claimed that the most vulnerable employees were working with high-risk occupations and considered the top priorities for the immediate action to control the spread of COVID-19. As recommended by Akkoyun and Kartin (2020), although new protocols for the preventive and protective measures in the workplace that company owners or employers could adopt and incorporate, the infestation of the COVID-19 may come unprecedented. Such an incident can be referred to as a "work accident" by companies. However, it would be the responsibility of the employers to take action for such an incident based on the Occupation Health and Safety (OHS) regulations against COVID-19. The aftermath signifies immense economic loss to the company due to stopping or limiting the operations and incurring additional costs for hospitalization, sanitation, and quarantine of the workers (Akkoyun and Kartin, 2020). Thus, it is imperative to investigate the impact induced by the COVID-19 pandemic on workplace safety.

OHS Vulnerability is generally correlated with elevated self-reported illness rates and work injury rates. However, according to Lay et al. (2016), vulnerability should not be described solely based on individual demographic characteristics because it neglects to account for how workers' unique circumstances influence their OHS risk. Presently, research on workplace vulnerability is the understudied area of occupational health and safety research in the oil and gas industry. Several studies in an occupationally diverse population adopt worker-reported measures to acknowledge how multiple workplace OHS contexts impact health risks. Thus, OHS Vulnerability Measures are utilized in the recent studies to evaluate workplace safety.

For instance, Çakıt et al. (2020) investigated the possible influence of tacit safety knowledge, attitudes toward safety (psychological aspects), attitudes toward safety (emotional aspects), safety culture (behavioral aspects), safety culture (psychological aspects), and the use of mobile technology to the perceived workplace safety among the workers. The authors reported that workplace safety was highly impacted by the tacit and explicit knowledge of the workers and that their behavioral aspects related to safety culture had a high association with the safety practices of the employees. Thus, these are the essential areas of OHS that the companies needed to improve to promote their workplace safety.

Moreover, in times of health crisis such as a pandemic like the COVID-19 outbreak, Walensky and Del Rio (2020) suggested that containment strategies should be integrated into the workplace, as part of the pandemic preparedness designed to mitigate community transmission. This could help decrease the worker's OHS vulnerabilities imposed by the health threats and promote a hazard-free workplace environment. Barnes and Sax, 2020 added that appropriate testing methods were effective in the accurate contact evaluation and follow-up for the pandemic mitigation and response. Early testing of the workers could also lessen the OHS vulnerability and workplace safety of other employees. In addition, rapid identification of COVID-19 cases corresponds to quick and early treatment of workers. Hence, the presented measures could explain how workers would feel vulnerable to OHS risks during COVID-19 within the oil and gas industry.

Therefore, the present study aimed to fill a gap of knowledge in this critical area. This study assessed Occupational Health and Safety (OHS) Vulnerability in five (5) areas: (1) Exposure to Workplace Hazards; (2) Policies and Procedures in the Workplace; (3) Perception on Health & Safety Culture in the Workplace; (4) Self-Awareness in Health & Safety Procedures and Responsibilities; and (5) Preventive Measure for Prevention of the Transmission of COVID-19 at Workplace. Specifically, this research aims to evaluate the degree of the workers' vulnerability to Occupational Health, and Safety (OHS) risks at work and attempt to prove that the five (5) areas of Occupational Health and Safety (OHS) Vulnerability Measure has a significant impact to Workplace Safety with the utilization of Partial Least Square - Structural Equation Modelling (PLS-SEM). PLS-SEM is a variance-based statistical analysis model utilized to test the hypotheses and a second-generation multivariate technique for evaluating structural models (Sohaib et al., 2020).

Also, this study explores how the five areas are interconnected, but conceptually distinct types of vulnerability are associated with socio-demographic and work characteristics and describes Occupational Health and Safety (OHS) vulnerability across a diverse sample of workers in the Oil and Gas Industry (OGI).

The remainder of this study is organized as follows. Theoretical frameworks are presented in sections 2 and 3, correspondingly. In section 4, the methodology is discussed. Finally, the findings, conclusions, and recommendations are discussed in sections 5 and 6, respectively.

2. Occupational health and safety in oil and gas

2.1. Occupational safety and health (OSH) and during COVID-19 pandemic

Considering the potential effect on the local communities and the environment holistically, OSH refers to the science of the anticipation, recognition, evaluation, and hazard control caused or resulting from the workplace that could affect the health and well-being of workers (Alli, 2008). Alli (2008) claimed that to extend the protection of both workers and the environment, a wide range of structures, experiences, knowledge, and analytical capacities are needed to regulate and implement all the "building blocks" that build up the national OSH systems—encompassing multiple disciplines and numerous workplace and environmental hazards (Min et al., 2019).

WHO (2017) focuses on three different objectives in connection to occupational health: (1) maintaining and promoting the health and working capacities of the workers; (2) improving the work environment and making it conducive to safety and health, (3) the developing work organizations and cultures in a direction that supports health and safety while promoting a positive social climate and smooth operation that could help increase the efficiency of the undertakings.

The term "working culture" refers to an organization's fundamental value structures where culture is considered in practice in the organizational systems, project quality management, principles for cooperation, personnel regulation, and training policies (Hussein Ali et al., 2017).

In the recent report by the World Health Organization (2021), it is mentioned regarding to occupational health and safety for health workers the following key points: (a) Amidst COVID-19, health workers should have the rights to decent, healthy and safe working conditions; (b) COVID-19 primary prevention of health care workers should be focused on risk assessment and implementation of appropriate measures; (c) other occupational risks exacerbated by the COVID-19 pandemic, *i.e.*, violence, harassment, stigma, discrimination, heavy workload and continued utilization of personal protective equipment (PPE) should be addressed; (d) all health workers should have access to occupational health care, mental health and psychosocial resources, as well as proper sanitation, hygiene, and rest facilities; (e) health-care facilities should have occupational health programmes in conjunction with programmes for infection prevention and control; (f) employers are responsible for ensuring that the necessary preventive and safety measures are taken to mitigate occupational risks for health workers.; (g) and lastly, health workers must adhere to established guidelines in order to protect their health and safety at work.

2.2. Occupational health and safety (OSH) vulnerability

OHS vulnerability refers to the situations in which workers are exposed to hazards in combination with inadequate protection to protect them from these hazards, with protections including OHS policies and procedures, awareness of OHS rights and responsibilities (Yanar et al., 2018), or a workplace culture that encourages worker participation in safety (Smith et al., 2020). According to the Expert Advisory Panel on Occupational Health and Safety of 2015, vulnerable workers have greater exposure to health and safety hazards than most workers and lack the power to alter those conditions.

Inadequate protection of workers exposed to hazards are at greater risk of injury and illness, and also, supervisor activities have been associated with injury risk (Premji and Smith, 2013). Yanar et al. (2019) claimed in their study that lack of supervisor assistance and OHS vulnerability in the workplace alone progressed the likelihood of physical injuries. In connection, the result of crude and adjusted models revealed that workers with a supportive supervisor were at less risk, unlike workers experiencing both OHS vulnerability and a lack of supervisor, which has at least 3.5 times higher risk of physical injury. It implies that the presence of a supportive supervisor would influence the risk level of the workers. Accordingly, vulnerable workers were at less risk if they had a supportive supervisor.

3. Partial least square - structural equation modeling and smartpls

Partial Least Square - Structural Equation Modeling (PLS-SEM) is a non-parametric approach that makes no distributional assumptions and can evaluate small sample sizes (Hamdollah and Baghaei, 2016). It is a research instrument utilized to quantify dynamic cause-effect relationship models with latent variables in various disciplines (Cepeda-Carrion et al., 2019). Hair et al. (2014) claimed that PLS-SEM's methodological toolbox could accommodate more complex model structures and handle data inadequacies such as heterogeneity. This emerging statistical approach could substantially provide higher statistical power, making it a better alternative to covariance-based structural equation modeling, as supported by Leguina (2015). PLS-SEM has now become a popular statistical technique (Kumar and Purani, 2018).

The analysis of this approach can be aided by SmartPLS, a robust software application with an accessible graphical user interface (Sarstedt and Cheah, 2019) that was developed by Ringle et al. (2005). According to Wong (2013), it is one of the prominent software applications for analyzing PLS-SEM data. Moreover, SmartPLS is a user-friendly application that can help researchers perform complicated computations in the most straightforward manner (Sabri & Wan Mohamad Asyraf, 2014).

3.1. Applications of PLS-SEM and SmartPLS on the HSE sector

In relation to the context of this study, some publications supported the usefulness of PLS-SEM in the health, safety, and environment (HSE) sector. The studies of Machfudiyanto et al. (2017), Wu et al. (2015), and Han et al. (2020) used a similar approach to assess different dimensions influencing workplace safety in the construction sector. The results of Machfudiyanto et al. (2017) explicated that all dimensions were interrelated and significant in establishing the safety culture. The safety-climate study by Wu et al. (2015) centered on representing common dimensions and specific dimensions and also relationships among the common dimensions. These dimensions involve the following: leadership, behavior, value, strategy, policy, process, employee, safety cost, and contract system. Han et al. (2020) investigated the internal relationships between safety investments and construction employees' behavioral performance with safety cognition as the mediating factor. The authors concluded that five areas in the Occupational Health and Safety (OHS) Vulnerability Measure would directly affect workplace safety. Further, the PLS-SEM could be extended with other methods. An example of this is the study of Çakıt et al. (2020), which employed an adaptive neuro-fuzzy inference system (ANFIS) approach assisted by PLS-SEM to appraise the connections within employees' implicit (tacit) and explicit (formal) safety knowledge and their impacts on safety at work.

Another comparable investigation assessed the correspondences between the characteristics of the nursing practice environment, job outcomes, and safety climate and observed their effects on the working environment (dos Santos Alves et al., 2017). Moreover, Kaynak et al. (2016) verified the accounts of the PLS-SEM approach to examine the effect of OHS practices on job performance, organizational commitment, and work alienation as throughput of such practices, in which the findings of the study show significant results.

Moreover, there are still vast opportunities in using PLS-SEM and SmartPLS in the HSE industry. Thus, its further application warrants more investigations, especially during a pandemic such as the COVID-19, when workplace safety in various industries is at high risk.

3.2. Other applications of PLS-SEM and SmartPLS

PLS-SEM and SmartPLS software utilization has been widely considered in various disciplines because of their notable methodological features. For instance, Sarstedt et al. (2014) demonstrated the usefulness of PLS-SEM in the field of family business research, particularly in developing family business strategies. The study showcased the flexibility of PLS-SEM on relationship specification, data requirements, and model complexity. In the abovementioned study, the authors investigated the relationships of "strategic information sharing" and "innovation" with "relationship value" and how "strategic information sharing" could impact "innovation" in a family business. The authors also further studied how family influence, which was defined by three constructs, namely "family power," "family culture," and "family experience," could affect the "strategic information sharing" and "innovation" in a family business. The results of their study revealed that both family experience and power were significant drivers of strategic information sharing and that a family experience could affect innovation.

Moreover, the study proved that strategic information sharing among a family could lead to business innovation. Further, the results revealed that both strategic information sharing and innovation were significant predictors of "relationship value" in a family business. Thus, the exploratory research of Sarstedt et al. (2014) had provided a clearer understanding that PLS-SEM could work efficiently in estimating path models with several constructs, indicators per construct, and structural paths. It also addressed the constraints in analyzing data with small sample sizes, which is common in family business research.

Further, some of the other exploratory studies that had contributed to the growing global research outputs on the integrated applications of PLS-SEM and SmartPLS include the articles of Sabri and Afthanorhan (2014), which examined where motivation in a volunteerism program could be derived from and then extended the tool to importance-performance matrix analysis; Ignacio et al. (2019), which predicted the behavioral intention of potential users of a circular economy-based sanitation technology with the combined technology acceptance model and theory of planned behavior (C-TAM-TPB) as the theoretical foundation; Dael et al. (2017), which elucidated the factors affecting the intention to use and intention to learn of the students concerning lectures on bioenergy through a standardized PowerPoint.

4. Methodology

4.1. Study approach

The current study explored the properties of the Partial Least Square – Structural Equation Modelling for evaluating the predictors of workplace safety in the oil and gas industry during the COVID-19 pandemic. Fig. 1 showed the research workflow responding to the research problem that this study aimed to address. The analysis of the research model using the PLS-SEM method was performed in three significant steps, which is similar to the workflow followed by Ignacio et al. (2019). The subsequent subsections provided pertinent details on the methods performed in this study.

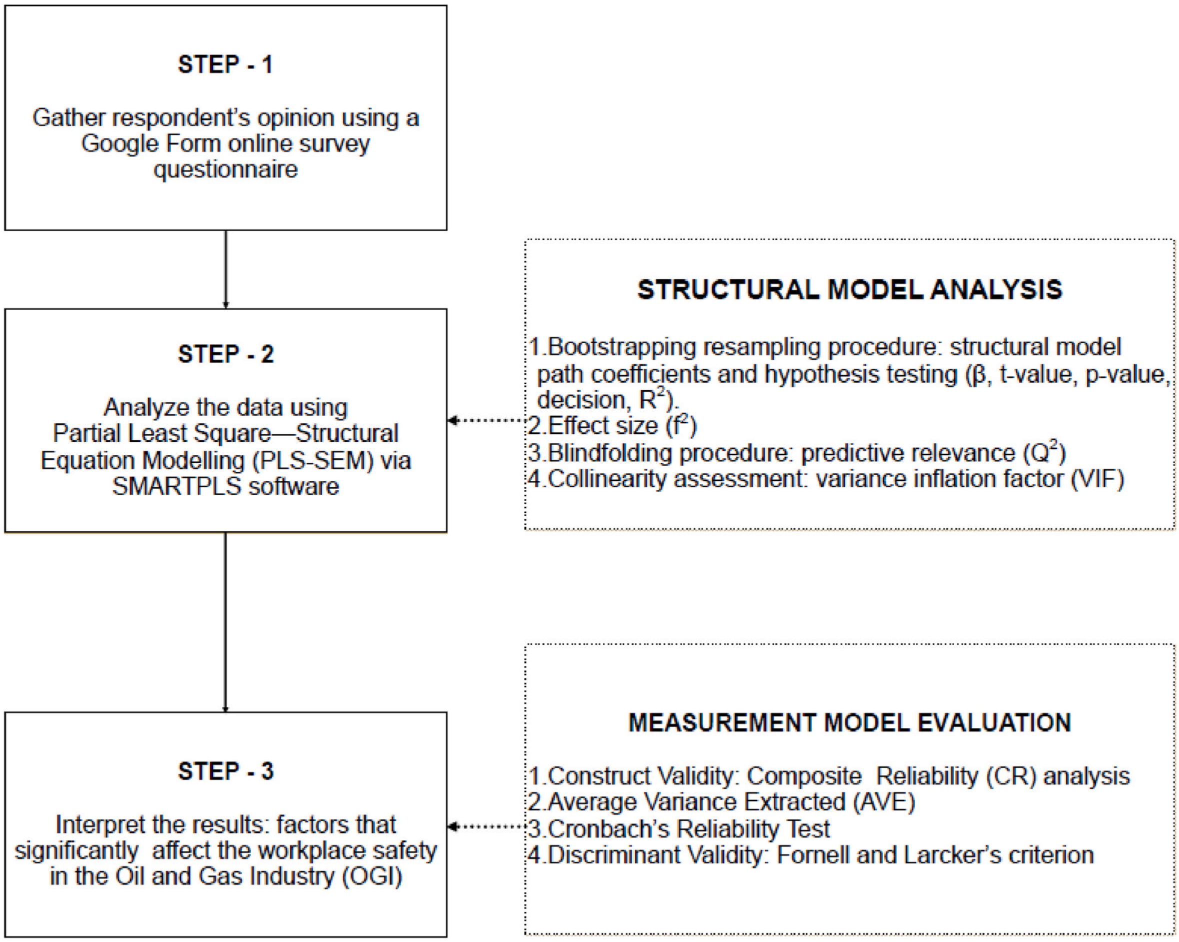

Fig. 1. Flowchart of the Workplace Safety model data analysis.

4.2. Model development

The principal construct of the proposed model for Occupational Health and Safety (OSH) Vulnerability Measure and assessing workplace safety were aligned with the work of the Institute for Work and Health (IWH) and Çakıt et al. (2020). The set of variables used in the PLS-SEM model included the following:

1. Exposure to Workplace Hazard (EWH) centers on all the kinds of health and safety hazards that workers can easily be exposed to while working.
2. Policies and Procedures in the Workplace (PPW) explore policies and systems already in place that decrease the probability of risk in the workplace.
3. Perception of Health & Safety Culture in the Workplace (PHSCW) includes the perception of occupational health and safety and involves awareness of hazards, the rights, and responsibilities of both employees and employers.
4. Self-Awareness in Health & Safety Procedures and Responsibilities (SAHSPR) focuses on a worker's ability to ask questions about health and safety and their ability to participate in it.
5. Preventive Measure for the Transmission of COVID-19 (PMTC19) emphasizes the prevention of all possible transmission of Covid-19
6. Workplace Safety (WS), defined as the tendency to follow safety regulations and safe work practices.

The survey statements for each study variable were shown in Table 1 below.

4.3. Study model, variables, and hypothesis

This study focused on assessing the Occupational Health and Safety (OSH) Vulnerability and attempting to utilize the five (5) areas has a significant impact on Workplace Safety by utilizing an advanced software, SmartPLS, with a graphical user interface for variance-based Structural Equation Modeling (SEM) using the partial least squares path modeling method (PLS) (Cepeda-Carrion et al., 2019). Also, the current study measures the extent to which a worker may be vulnerable to Occupational Health and Safety (OSH) risks at work and pinpoint areas that may need improvement to protect the health and safety of workers better.

The study model and hypothesis adopted in this study were based on previous research (Lay et al., 2016). These elements are presented in Fig. 2 and Table 2.

4.4. Subject area

The study was conducted through an online survey with professionals from the oil and gas industry worldwide. The oil and gas sector is a global powerhouse producing hundreds of billion dollars internationally by managing great numbers of workers (Muspratt, 2019). According to the recent statistics of the International Labour Organization, nearly 6 million people are directly employed and over ten times that number of jobs are indirectly created by the industry in the petroleum industry. However, in the Philippines, Montallana et al. (2019) mentioned that, due to data suppression implemented by the Department of Energy (DOE), there is no exact number of workers employed in the Oil and Gas Industry.

Table 1
Model constructs with corresponding item measures and descriptions.

Construct	Item	Description
Exposure to Workplace Hazards (EWH)	EWH1.	Stand for more than 2 h nonstop
	EWH2.	Experience bullying or harassment at work
	EWH3.	Raise your voice to communicate with your co-workers 1 m away due to a noisy atmosphere
	EWH4.	Work at a height that is 2 m or higher above the ground.
	EWH5.	Have to work with poor or awkward posture.
	EWH6.	Interact with chemicals, flammable liquid and gases, and other hazardous substances.
	EWH7.	Perform tasks or use work methods unfamiliar to you.
	EWH8.	Use your hands for packing, sorting, assembling, cleaning, pulling, pushing, typing, etc., for at least 3 h a day
	EWH9.	Carry, push, or manually lift items heavier than 20 kg at least 10 times during the day.
	EWH10.	Working in a confined space with the potential presence of toxic and flammable gases and low oxygen content.
	EWH11.	Working in machinery with parts that are not properly guarded.
	EWH12.	Working with materials that are considered explosive or can create a violent reaction with other substances.
	EWH13.	Working in extreme weather conditions (extreme hot or cold areas).
Policies and Procedures in the Workplace (PPW)	PPW1.	Communication on workplace health and safety procedures is comprehensible.
	PPW2.	Incidents and accidents are investigated quickly to improve workplace health and safety.
	PPW3.	There is an active health and safety committee and/or worker health and safety representative.
	PPW4.	Workplace health and safety is deemed as important as the production and services
	PPW5.	Protocols are in place to identify, prevent and deal with hazards at work.
	PPW6.	Safety issues are a regular subject between the employees and the management.
	PW7.	Everyone is given necessary workplace health and safety training when beginning or changing jobs or when using new techniques.
Perception of Health & Safety Culture in the Workplace (PHSCW)	PHSCW1.	I know my rights and responsibilities in relation to workplace health and safety
	PHSCW2.	I know my employers' rights and responsibilities in relation to workplace health and safety
	PHSCW3.	I know how to accomplish my job safely
	PHSCW4.	If I was aware of a safety hazard at my workplace, I know to the person I need to report to in my workplace.
	PHSCW5.	I have the required knowledge to aid in responding to any health and safety concerns at my workplace.
	PHSCW6.	I know the necessary precautions that I should take while doing my job.
Self-Awareness in Health & Safety Procedures and Responsibilities (SAHSPR)	SAHSPR1.	I feel free to critic or make suggestions about workplace health and safety.
	SAHSPR2.	If I become aware of a workplace hazard, I would inform the management.
	SAHSPR3.	I know that I can stop working if I think something is unsafe and management will not reprimand me for doing so.
	SAHSPR4.	If my work environment was safe I would say anything, and this will improve my co-workers performance and work environment will be safer.
	SAHSPR5.	I can finish my work safely without being impeded by time
Preventive Measure for the Transmission of COVID-19 at the workplace (PMTC19W)	PMTC19W1.	I practice regular and thorough handwashing with soap and water or hand hygiene with alcohol-based hand-rub.
	PMTC19W2.	It is important to develop a policy on wearing a mask or a face covering in line with national or local guidance.
	PMTC19W3.	Medical face masks and paper tissues are must be always available at the workplace
	PMTC19W4.	Decreasing the density of workers or employees can help to prevent transmission of the virus in the workplace
	PMPTC19W5.	Social gathering in the workplace that involve close and prolonged contact among participants must be suspended.
	PMTC19W6.	Government agencies and World Health Organization (WHO) must be used as an official source in providing regular information about the risk of COVID-19
	PMTC19W7.	I have been monitoring myself for symptoms of COVID-19, such as taking a body temperature regularly.
	PMTC19W8.	It is essential for the company to use a thermal scanner at the workplace.
	PMTC19W9.	It is important for the company to issue a standard procedure for those who become sick at the workplace or are suspected of having COVID-19, do follow-up cleaning and disinfection after a suspected case of COVID-19, and keep attendance meeting records to facilitate contact tracing.
Construct	Item	Description
Workplace Safety (WS)	WS1.	I acknowledge the person to report in the issue of a system breakdown or an accident at work.
	WS2.	

(continued on next page)

Table 1 (*continued*)

Construct	Item	Description
		I always follow procedures for dealing with machine breakdowns or safety hazards
	WS3.	I inform my superiors about any potential threats in work safety that I observe
	WS4.	I do not use equipment that, in my opinion may pose a safety hazard.
	WS5.	I know the placement of fire extinguishers in my work environment.
	WS6.	I always use appropriate protective clothing as required

4.5. Survey instrument

The researchers generated a survey instrument to evaluate the significant factors affecting workplace safety in the Oil and Gas Industry (OGI) during the COVID-19 Pandemic. The questionnaire in this study was divided into six (6) segments: (1) Profile of Respondents; Questionnaires on: (2) Policies and Procedures in the Workplace; (2) Exposure to Workplace Hazards; (3) Perception on Health & Safety Culture in the Workplace; (4) Self-Awareness on H&S Procedures and Responsibilities; (5) Preventive Measure for the Transmission of Covid-19 at Workplace; and (6) Workplace Safety.

4.6. Measurement scale

All questionnaire items were measured using a five-point Likert scale: (1) strongly disagree/never; (2) disagree/rarely; (3) neither agree nor disagree/seldom; (4) agree/sometimes; and (5) strongly agree/always.

4.7. Data collection

For this study, a non-probability purposive sampling approach was utilized for collecting data in the study area. A link to the google forms was distributed to individuals currently working in the international or local oil and gas companies through email or via social media, depending on the respondents' convenient online approach. Responses to the survey were automatically collected using Google Forms and connected to a Google spreadsheet to be extracted as an Excel file.

4.8. Data analysis

Before importing the data to the software used for the analysis, it is essential to convert the data into the suitable format required by the tool. These include data cleaning and editing. The purpose of this these steps is to ensure that there will be no incomplete data in the analysis, and that datasets will be valid for the item that they want to measure.

In this study, all datasets proceeded with the analysis since all respondents completed answering each questionnaire item. However, some data were edited because they were stated negatively. For instance, in the current study, the main objective was to determine the possible predictors of Workplace Safety (WS). Thus, all constructs should complement WS. However, the description of one construct (i.e., "Exposure to Workplace Hazards (EWH) would compromise WS. Previously, in Table 1, the indicators of EWH represented different scenarios of EWH. If the original data were retained, a score of five (5) would indicate a strong agreement to the frequency of exposure to workplace hazards, which would oppose the values of workplace safety. Hence, the measurement scores were inverted to reverse the description of EWH. Thus, a score of five (5) would then be interpreted as the strong agreement of the respondents to non-exposure to workplace hazards.

Table 2
Study hypotheses.

#	Hypotheses
H1	Identification of exposure to workplace hazards has a significant effect on workplace safety.
H2	Policies and procedures in the workplace have a significant effect on workplace safety.
H3	Perception of health & safety culture in the workplace has a significant effect on workplace safety.
H4	Self-awareness in health & safety procedures and responsibilities has a significant effect on workplace safety.
H5	Preventive measure for preventing transmission of covid-19 at the workplace has a significant effect on workplace safety.

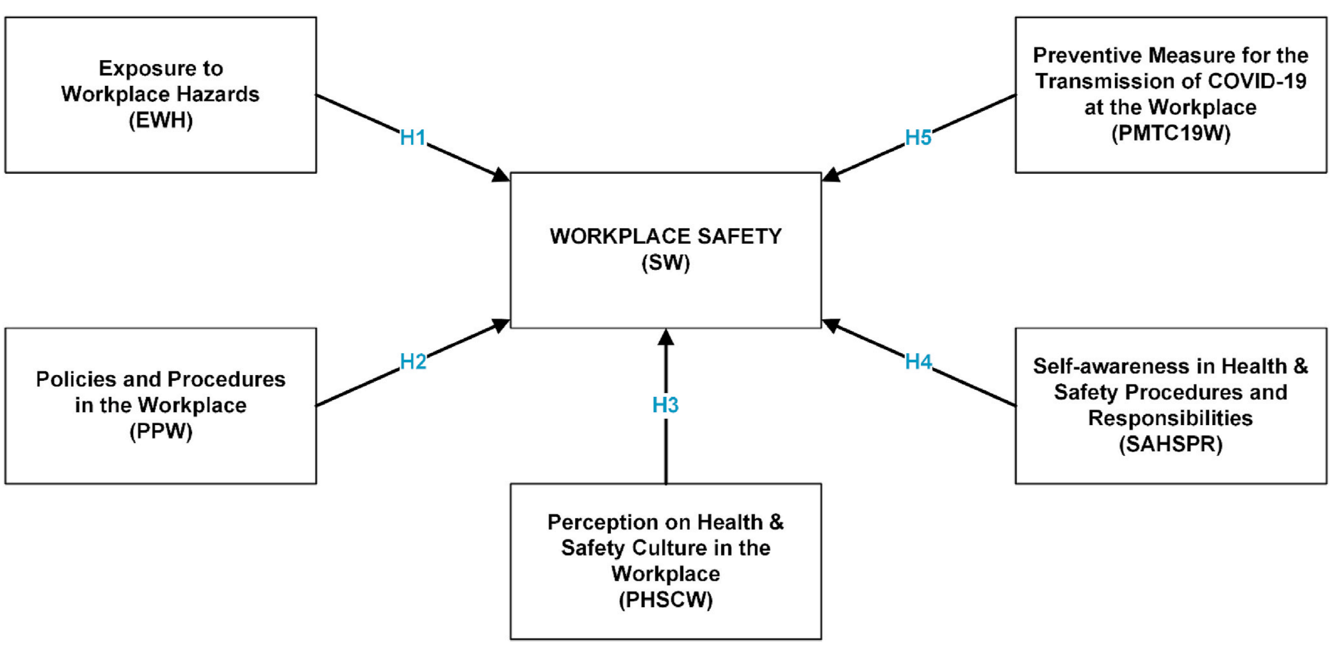

Fig. 2. The hypothesized study model.

The pre-processed data was eventually imported to SmartPLS 3 (v. 3.3.3) software, one of the leading software for Partial Least Square-Structural Equation Modelling (PLS-SEM) for data analysis. This study took advantage of advanced statistical and soft computing modeling techniques that could be performed using the software. The initial data processing performed in SmartPLS 3 was the construction of model similar to Fig. 2. This represented the path model of the hypothesized PLS-SEM model. Once the model was established, it was analyzed using two distinct assessment techniques: measurement model and structural model assessments. Both of these models can be analyzed simultaneously using the software while providing precise and reliable results.

5. Results and discussion

5.1. Demographic profile of the respondents

This study gathered data from 50 professionals working in the oil and gas industry in different companies and countries (*i.e.*, Philippines, Denmark, United Kingdom, United States of America, Saudi Arabia, and the United Arab Emirates). Fig. 3 shows the location of the respondents with their respective professions.

The majority of the respondents (32) were 25–44 years old, sixteen were 22–24 years old, and only two were 45 years old and above. Their gender composition was 94% male and 6% female. Most of the respondents were working as site H_2S specialists/technicians (12%), followed by HSE adviser/consultant (6%) and field engineers (6%). A huge population proportion of these respondents was comprised of direct company employees. Nineteen of the respondents were new in the oil and gas industry (0–3 years). Similarly, there were also nineteen employees working for 4–9 years. The rest of the respondents were in the industry for at least 10 years. Lastly, almost 50% of the respondents served in the downstream sector, followed by those who work upstream (38%), then 8% were office-based, and 6% in the midstream.

5.2. Empirical findings on the hypothesized PLS–SEM model via SmartPLS

This study employed PLS-SEM to assess the developed theoretical model for evaluating workplace safety in the oil and gas industry during the COVID-19 pandemic. PLS-SEM technique scrutinized the research hypothesized model, associated hypotheses, and other statistical analysis through SmartPLS (v 3.3.3.) software. These analyses consisted of two (2) sections; measurement model assessment and structural model measurement. The PLS-SEM analysis was conducted simultaneously for structural and measurement models, resulting in more precise results, making it a good fit for this investigation.

5.2.1. Measurement model assessment

Several statistical tests were employed to assess the measurement model. In Table 3, each construct and its respective indicators were tabulated with the results of the outer loadings, internal consistency, and convergent validity tests. A discriminant validity test was also performed using Fornell-Larcker criterion, as seen in Table 4.

The first procedure involved a test of the contributions of items (indicators) to their respective construct, which was represented by the outer loadings. The software generated the values for the outer loadings by computing the bivariate correlations between the indicators and their respective construct. Any indicator with outer loading below the 0.50 threshold would indicate weak contributions of indicator to the construct and should be removed from the model. In this study, the outer loadings of the 46 indicators of the initial hypothesized model were compared to the threshold value. Three (3) of the indicators from the Exposure to Workplace Hazards (EWH) construct, namely EWH1 (stand for more than 2 h nonstop), EWH2 (experience bullying or harassment at

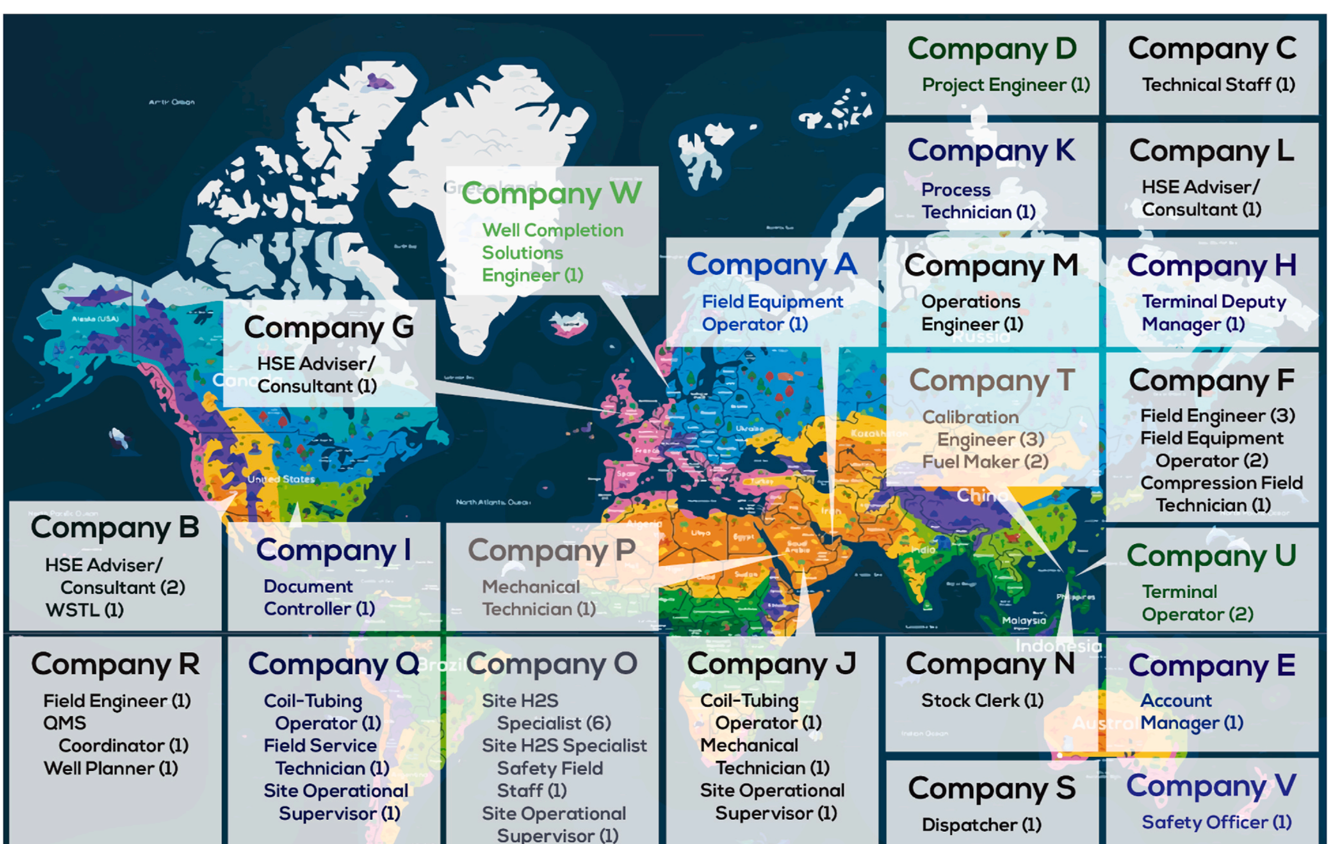

Fig. 3. Location of the respondents with their respective companies and job positions.

Table 3
Reliability and convergent validity of the final structural model.

Construct (Latent Variable)	Indicators	Outer Loadings	Cronbach's Alpha (α)	Composite Reliability (CR)	Average Variance Extracted (AVE)
Exposure to workplace hazards	EWH4	0.686	0.859	0.881	0.43
	EWH5	0.660			
	EWH6	0.689			
	EWH7	0.641			
	EWH8	0.600			
	EWH9	0.680			
	EWH10	0.656			
	EWH11	0.699			
	EWH12	0.659			
	EWH13	0.546			
Policies and procedures in the workplace	PPW1	0.862	0.992	0.937	0.68
	PPW2	0.823			
	PPW3	0.879			
	PPW4	0.767			
	PPW5	0.902			
	PPW6	0.835			
	PPW7	0.691			
Perception on health & safety culture in the workplace	PHSCW1	0.779	0.869	0.905	0.66
	PHSCW2	0.867			
	PHSCW4	0.846			
	PHSCW5	0.655			
	PHSCW6	0.889			
Self-awareness in health & safety procedures and responsibilities	SAHSPR1	0.811	0.704	0.811	0.47
	SAHSPR2	0.537			
	SAHSPR3	0.726			
	SAHSPR4	0.606			
	SAHSPR5	0.701			
Preventive measure for the transmission of covid-19 at the workplace	PMTC19W1	0.644	0.780	0.839	0.40
	PMTC19W2	0.650			
	PMTC19W3	0.698			
	PMTC19W4	0.584			
	PMTC19W5	0.500			
	PMTC19W6	0.799			
	PMTC19W7	0.586			
	PMTC19W9	0.539			
Workplace safety	WS1	0.813	0.766	0.849	0.53
	WS2	0.561			
	WS3	0.768			
	WS4	0.800			
	WS5	0.682			

Table 4
Fornell–larcker criterion.

	AVE	EWH	PHSCW	PMPTC19W	PPW	SAHSPR	WS
EWH	0.43	**0.65**					
PHSCW	0.66	0.29	**0.81**				
PMPTC19W	0.40	0.52	0.70	**0.63**			
PPW	0.68	0.34	0.40	0.32	**0.83**		
SAHSPR	0.47	0.29	0.74	0.66	0.51	**0.68**	
WS	0.53	0.36	0.86	0.78	0.29	0.71	**0.73**

work), and EWH3 (raise your voice to communicate with your co-workers 1 m away due to a noisy atmosphere), had outer loadings of <0.50, resulting to its removal. The revised PLS-SEM model was re-run in the SmartPLS software, and all outer loadings were above the threshold, as seen in Table 3.

In other studies, such as in the study of Hair et al. (2012), the suggested threshold for outer loadings was 0.70. However, Awang (2012) suggested that a threshold value of 0.50 may be accepted if the indicators are not yet established. Otherwise, for established models, the threshold should be 0.60. The 0.50 threshold value was also suggested by Hair et al. (2020).

The following procedure was to test the internal consistency of the revised PLS-SEM model. There were two parameters considered: Cronbach's alpha (α) and Composite Reliability (CR). Both of these parameters were used to determine the similarities of the scores of the indicators per construct. The difference between these two is that Cronbach's alpha assumes the equality of the loadings of the indicators while the Composite Reliability does not. Both of these parameters share the same threshold value of 0.70. In this study, all constructs were able to satisfy the threshold for internal consistency reliability test.

For the convergent validity test, the average variance extracted (AVE) was calculated. The AVE is the quantity of the amount of variance taken via a latent variable regarding the measurement error caused by the amount of variance (Hair et al., 2019a,b). The acceptable value for AVE is 0.60 as recommended by Fornell and Larcker (1981). In this study, all items fulfilled the recommended ranges for Average Variance Extracted (AVE) except for "Exposure to Workplace Hazards (EWH)", Self-awareness in Health & Safety Procedures and Responsibilities

(SAHSPR)", and "Preventive Measure for the Transmission of COVID-19 at the Workplace (PMTC19W)".

The AVE of 'exposure to workplace hazards' (O.43), 'self-awareness in health & safety procedures and responsibilities' (0.47), and 'preventive measure for the transmission of COVID-19 at the workplace' (0.40) were considered low. In connection to the recommendation of Fornell and Larcker (1981), AVE values below the 0.5 thresholds are still acceptable, only if the composite reliability (CR) is greater than 0.60. The tolerable range of AVE is 0.40–0.50. Nevertheless, an AVE below the lowest tolerable value (0.40) will no longer be accepted. Based on the results, the composite reliability scores of "exposure of workplace hazards", "self-awareness in health & safety procedures and responsibilities", and "preventive measure for the transmission of COVID-19 at the workplace" were 0.880, 0.811, and 0.839, respectively. Therefore, it was reasonable to accept the AVE reading for these constructs since their composite reliability scores were above 0.60.

Table 4 confirmed the discriminant validity of all remaining constructs. The discriminant validity shows how distinct each construct from each other. The square root of AVE per construct was calculated to obtain the cross-loadings of each construct. The cross-loadings of each construct (represented by the underlined bold numbers) must be higher than their respective AVEs to confirm discriminant validity (Hair et al., 2019a,b). This was to verify if the constructs are appropriate in representing each corresponding constructs.

All items should be comparable to or greater than the recommended values per the rule of thumb. If not, these items should be removed before the next part of the analysis, the discriminant validity test. Nevertheless, it is essential to inspect the problematic variables before removing the items (Ignacio et al., 2019). The previously mentioned tests confirmed that the measurement model was suitable for the next part of the analysis, the structural model assessment.

5.2.2. Structural model assessment

PLS-SEM approach determines the degree which the hypothesized model was maintained and supported by the empirical data (Çakıt et al., 2020). It follows the assumptions of non-normal distribution. By performing a structural model assessment, the study forecasted the association among constructs or latent variables and estimated the accuracy of the model when performed in practice. Numerous parameters were observed for the evaluation of the structural model. These included path coefficient, t-statistics, p-value, effect size, coefficient of determination, variance inflation factor, and predictive relevance. Table 5 summarized the result of the structural model assessment.

The first part of the structural model assessment is to test the research hypotheses. The hypotheses were confirmed by calculating for the path coefficients, *t*-statistics, and *p*-values for each construct. Path coefficient is the partial correlation coefficient between the dependent and independent variables, adjusted for additional independent variables (Palese et al., 2019). In addition, it indicates the direct effect of a variable assumed a cause on another variable assumed to be an effect. A t-statistic is an unvarying value produced from sample data (Kim, 2015). The t-value expresses the magnitude of the difference in terms of the variation in your sample data. Notably, the higher the t-value, the greater our confidence in the coefficient as a predictor. The p-value, rather than rejection points, is used to determine the least level of significance at which the null hypothesis is rejected (Di Leo and Sardanelli, 2020). Performing a statistical value helps determine the significance of the result concerning the null hypothesis. A lower p-value indicates that there is more evidence supporting the alternative hypothesis.

Using the SmartPLS software, this is achievable through a non-parametric bootstrapping. Bootstrapping is a method of calculating statistical features such as sampling variances, standard errors, and confidence intervals without relying on a specific assumption about the shape of the distribution around a given statistic (Allen, 2017). A bootstrapping test is a resampling approach in which numbers of subsamples (5000 subsamples have typically been suggested) are generated (Kaya et al., 2020). In this study, bootstrapping with resampling of 500 repeated subsamples was also conducted in the scrutiny.

The result of the analysis revealed that only Perception on Health & Safety Culture in the Workplace (PHSCW) was a significant predictor of Workplace Safety in the oil and gas industry during the pandemic (*t*-value = 3.323; *p*-value = 0.001). It had a strong effect and relationship on Workplace Safety (WS) with β = 0.603. However, other constructs such as "Exposure to Workplace Hazard", "Policies and Procedures in the Workplace (PPW)", "Self-Awareness in Health & Safety Procedures and Responsibilities (SAHSPR)", and "Preventive Measure for Prevention of the Transmission of COVID-19 at Workplace (PMPTC19W)" had weak association with Workplace Safety during the COVID-19 pandemic. More importantly, the *p*-values for these constructs were below 0.005 threshold. Therefore, this study supported H3 and rejected H1, H2, H4, and H5.

The researchers also identified the model's R^2 to compute the quantity of variation in the dependent constructs caused by the independent values. The R^2 values of 0.75, 0.50, or 0.25 for dependent variables are considered substantial, moderate, and weak values, respectively. The R^2 value for Workplace Safety was 0.817 which means that 81.7% of the variance can be predicted by Perception on Health & Safety Culture in the Workplace.

Further, the effect size (f^2) evaluates how eliminating a particular predictor construct affects an endogenous construct's R^2 value (Hair et al., 2019a,b; Sun et al., 2018). Furthermore, it indicates the significance of a link between variables or a difference between groups (Sullivan and Feinn, 2012). Generally, it expresses the practical importance of study findings. A big effect size suggests that a study discovery has practical application, whereas a small impact size indicates that the research finding has limited application. Following Cohen (1988), large, medium, and small effect predictors have parameters $f^2 \geq 0.35$, $0.35 > f^2 \geq 0.15$, and $0.15 > f^2 \geq 0.02$, respectively. As substantial indicators, "Perception on Health & Safety Culture in the Workplace" greatly affects "Workplace Safety" with an f^2 reading of 0.731. "Preventive Measure for Prevention of the Transmission of COVID-19 at Workplace" has a medium effect on "workplace safety" ($f^2 = 0.177$). "Policies and Procedures in the Workplace", "Self-Awareness in Health & Safety Procedures and Responsibilities", and "Exposure to Workplace Hazard" have a small

Table 5
Hypothesis testing results.

Relationship	H	Path Coefficient (β)	t-statistics	p-value	Test result: Hypothesis	Model R^2	f^2	VIF	Q^2
EWH → WS	H1	0.040	0.482	0.630	Unsupported	0.817	0.006	1.494	0.381
PPW→ WS	H2	−0.133	1.284	0.200	Unsupported		0.066	1.466	
PHSCW→ WS	H3	0.603	3.323	0.001	Supported		0.731	2.704	
SAHSPR→ WS	H4	0.125	1.036	0.301	Unsupported		0.031	2.743	
PMPTC19W→ WS	H5	0.297	1.546	0.123	Unsupported		0.177	2.728	

*NOTE: p-value was considered significant at the 0.005 level.
**ABBREVIATION: Exposure to Workplace Hazard (EWH); Policies and Procedures in the Workplace (PPW); Perception on Health & Safety Culture in the Workplace (PHSCW); Self-Awareness in Health & Safety Procedures and Responsibilities (SAHSPR); and Preventive Measure for Prevention of the Transmission of COVID-19 at Workplace (PMPTC19W).

effect on Workplace Safety with $f^2 = 0.066$, $f^2 = 0.031$, and $f^2 = 0.006$, respectively.

A test for multicollinearity is the first step in model verification and was implemented to examine the extent of correlations between Independent Variables (Latent Variable). Multicollinearity was verified by an indicator of Variance Inflation Factor (VIF). According to Hair et al. (2019a,b) and Hair et al. (2014), all VIF values were below 5.0 (<5.0) and were considered acceptable measures. Multicollinearity is present when the VIF coefficient is higher than 5.0. Hence, it could be considered problematic according to the rule of thumb. In this study, the result also claimed that the VIF value of the significant predictor (PHSCW: VIF = 2.704) was within the acceptable limit. Overall, the largest VIF value was 2.743 (SAHSPR→ WS), and the lowest reading was 1.466 (PPW→ WS). The results specified that there was no multicollinearity existing on each construct, especially on the PHSCW.

Moreover, a blinding process was also included in the scrutiny to predict the validity of the model. This metric removes single points in the data matrix, imputes the removed points with the mean, and estimates the model parameters (Rigdon, 2014). Hair et al. (2019a,b) suggested that Q^2 values should be larger than zero ($Q^2 > 0$) to stipulate predictive accuracy of the structural model for the particular endogenous construct. Cross-validated redundancy was applied for the measurement of Q^2, where $Q^2 > 0$ is acceptable. Therefore, Q^2 value revealed that endogenous construct is within the acceptable limit for the predictive relevance test.

The results of this study confirmed the applicability of the Partial Least Equation Structural Equation Modeling in developing workplace safety models that are based in the occupation health and safety. The results also highlighted the importance of perception of health and safety culture in improving the workplace safety in the oil and gas industry. In a related study, the findings of Çakıt et al. (2020) demonstrated that OHS-safety culture-related perception (such as attitude, behavior, and other psychogical aspects) may indeed influence safety at work. Such a study would help improve work environment during a global health disaster such as the COVID-19 pandemic.

Recent studies utilized the Occupational Health and Safety (OHS) Vulnerability Measure to help pin down areas that may need enhancement to better protect the health and safety of workers, especially during the COVID-19 pandemic. Smith et al. (2021) cited that conventional design and implementation of employer-based infection control programs (ICP) had associations for site-based workers' mental health. In this regard, the study's findings confirmed that as economies reopen worldwide, promoting employer-based infection control policies would have significant ramifications for worker mental health. Additionally, Smith et al. (2020) scrutinized the relationship between mental health symptoms and perceived adequacy of personal protective equipment (PPE) and workplace-based infection control procedures (ICP) among a sample of Canadian healthcare workers in the context of the present COVID-19 pandemic. A similar study describing OHS vulnerability across a diverse sample suggested that knowing how labor market sub-groups experience different vulnerability types could inform better-tailored primary prevention interventions (Lay et al., 2016). In connection, Yanar et al. (2018) compared OHS vulnerability of contemporary Canadian immigrants and workers born in Canada, later on, the findings revealed that recent immigrant workers experience raised risk of OHS vulnerability.

Moreover, Rupakheti et al. (2018) identified the status and factors associated with OHS Vulnerability among brick factory workers in Dhading district, Nepal. OHS Vulnerability was very high among the brick factory workers (Rupakheti et al., 2018). A similar study in the field of micro-enterprises business, Park et al. (2017) evaluated the OHS dilemmas focusing on the features of micro-enterprises (companies with less than five workers). In this study, the authors concluded that assessing OSH Vulnerability amidst the COVID-19 Pandemic would provide valuable knowledge and could contribute to the progress of more appropriately tailored primary prevention initiatives by examining how diverse subpopulations are differently affected by each type of vulnerability in the oil and gas industry.

In the context of perception on health and safety culture in the petroleum and petrochemical industries, workers are exposed to several occupational hazards that may affect the quality of their workplace safety. These occupational hazards include noise, several types of chemicals, ionizing radiation, and infrared radiation, etc. (Ezejiofor et al., 2014). Although the workers are exposed to these threats, workers are aware of how to handle these undesirable situations and whom to call when undesired events occur within their workplace because of occupational health and safety (OHS) training provided to the oil employees gas industry.

Oil and gas employers must ensure that all their workers and supervisors complete a basic occupational health and safety awareness training program to meet the new regulatory requirements. Under the Occupational Health and Safety Act (OHSA), the Occupational Health and Safety Awareness and Training Rule (O. Reg. 297/13) is a new regulation that mandates companies to ensure that workers and supervisors complete a basic occupational health and safety awareness training program (Ministry of Labour, Training and Skills Development, 2013).

It is critical to raise awareness in the workplace, particularly among oil and gas employees and supervisors. The adoption of this regulation marks a turning point moment in health and safety history, with far-reaching implications for future generations.

Workplace safety is such a critical feature and responsible management of every inside oil and gas company and must guarantee that competent employees are recruited as Health and Safety officers to oversee workplace safety. When Safety Officers appear tenacious and tough to deal with on any problem in their workplace, other employees should recognize that this is due to the obligations they carry.

In OHS awareness-raising and training, building and maintaining a preventative safety and health culture require tripartite engagement to promote workplace safety in the oil and gas sector. International Labour Organization (2017) provides concrete guidance on the measures that can be taken to develop such a national culture. Including measures to raise awareness of OHS through national campaigns, and promote, at the workplace level the establishment of safety and health policies and joint safety and health committees and the designation of workers' OSH representatives, provide knowledge and encouragement to employers, workers, and their respective organizations, and many more.

Further, in a recent study conducted by Nkrumah et al. (2021), the authors measured Occupational Health and Safety Management (OHSM) practices utilizing a two-dimensional distinct construct that evaluates diverse features of positive work behaviors from six distinguished safety dimensional perspectives and work performance. The study claimed that a high perception of H&S culture in the workplace should lessen the impact of being exposed to hazardous conditions.

Finally, the results suggested that hazards, including the threats of the COVID-19, would create little to no impact on the workplace safety in the oil and gas industry as long as they are equipped with a positive perception and attitude toward health and safety culture. This is attainable with sufficient knowledge and skillsets that can be acquired from OHS training and other precursors of OHS. However, this type of relationship should be investigated further in future studies.

6. Conclusions and recommendation

The central application of this study was to apply Partial Least Squares Structural Equation Modeling (PLS-SEM) to model workplace safety in the Oil and Gas Industry. The study aimed to evaluate the relationships between the five (5) areas of the Occupational Health and Safety (OHS) Vulnerability Measure (Exposure to Workplace Hazard, Policies and Procedures in the Workplace, Perception on Health & Safety Culture in the Workplace, Self-Awareness in Health & Safety Procedures and Responsibilities, and Preventive Measure for Prevention of the

Transmission of COVID-19 at Workplace), and their effects on workplace safety. These are defined as the tendency to follow safety regulations and safe work practices within the workplace.

This study verified the advantages of PLS-SEM in the assessment of the hypothesized model. Additionally, the PLS-SEM was able to explicate each latent variable's significance, strength, and collinearity level. The findings of this study were able to support the tested hypothesis through bootstrapping, and it revealed that only Perception of Health & Safety Culture positively affects workplace safety in the Oil and Gas Industry during the COVID-19 pandemic.

Nonetheless, some empirical interpretations during the analysis suggested that there is still a need to enhance the survey questionnaire. Suppose a similar questionnaire is utilized for future or further research. In that case, this study recommends to improve further the measurement items (e.g., increasing the number of measurement items, modification of the measurement items) to avoid low reliability and increase the validity of indicators, enhance and add more factors affecting workplace safety, and increase the number of respondents to increase the validity indicators.

The presented results can be used in the future to develop a safety knowledge management system that enhances the areas from Workplace Hazard, Policies and Procedures in the Workplace, Self-Awareness in Health & Safety Procedures and Responsibilities, and Preventive Measure for Prevention of the Transmission of COVID-19 at Workplace to improve the overall safety performance within the Oil and Gas Industry. This study could serve as a hypothetical basis for companies to further develop occupational health and safety program.

Declaration of competing interest

The authors declare no conflict of interest.

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References

Akkoyun, M.B., Kartin, E., 2020. The Effects of Cororavirus (Covid-19) on Occupational Health and Safety and an Evaluation within the Scope of Work Accidents. https://www.mondaq.com/turkey/employment-and-workforce-wellbeing/914232/the-effects-of-coronavirus-covid-19-on-occupational-health-and-safety-and-an-evaluation-within-the-scope-of-work-accidents.

Allen, M., 2017. The Sage Encyclopedia of Communication Research Methods, vols. 1–4. SAGE Publications, Inc, Thousand Oaks, CA. https://doi.org/10.4135/9781483381411.

Alli, B., 2008. Fundamental Principles of Occupational Health and Safety, second ed. International Labour Organization, ISBN 978-92-2-120454-1 https://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_093550.pdf#:~:text=Occupational%20safety%20and%20health%20%28OSH%29%20is%20generally%20defined,impair%20the%20health%20and%20well-being%20of%20workers%2C%20takingintoaccountthepossibleimpactonthesurroundingcommunitiesand.

Awang, Z., 2012. Research Methodology and Data Analysis, second ed. Universiti Teknologi Mara, UiTM Press, ISBN 978-967-363-422-4.

Barnes, M., Sax, P.E., 2020. Challenges of "return to work" in an ongoing pandemic. N. Engl. J. Med. https://doi.org/10.1056/nejmsr2019953.

Blunt, R., Thomson, P., Bory, O., 2020. The Impact of COVID-19 on the Oil and Gas Industry Many. https://www.bakermckenzie.com/en/insight/publications/2020/04/the-impact-of-covid19-on-the-oil-and-gas-industry.

Çakıt, E., Olak, A.J., Karwowski, W., Marek, T., Hejduk, I., Taiar, R., 2020. Assessing safety at work using an adaptive neuro-fuzzy inference system (ANFIS) approach aided by partial least squares structural equation modeling (PLS-SEM). Int. J. Ind. Ergon. 76 (August 2019), 102925. https://doi.org/10.1016/j.ergon.2020.102925.

Campbell, L., 2020. Oil rig workers hit with one-two punch of coronavirus and plummeting oil prices. https://www.nbcnews.com/news/us-news/oil-rig-workers-hit-one-two-coronavirus-plummeting-oil-prices-n1178751.

Cepeda-Carrion, G., Cegarra-Navarro, J.G., Cillo, V., 2019. Tips to use partial least squares structural equation modelling (PLS-SEM) in knowledge management. J. Knowl. Manag. 23 (1), 67–89. https://doi.org/10.1108/JKM-05-2018-0322.

Cohen, J., 1988. Set correlation and contingency tables. Appl. Psychol. Meas. 12 (4), 425–434. https://doi.org/10.1177/014662168801200410.

Dael, M. Van, Lizin, S., Swinnen, G., Passel, S. Van, 2017. Young people ' s acceptance of bioenergy and the in fluence of attitude strength on information provision. Renew. Energy 107, 417–430. https://doi.org/10.1016/j.renene.2017.02.010.

Di Leo, G., Sardanelli, F., 2020. Statistical significance: p value, 0.05 threshold, and applications to radiomics—reasons for a conservative approach. Eur. Radiol. Exp. 4 (1) https://doi.org/10.1186/s41747-020-0145-y.

dos Santos Alves, D.F., da Silva, D., de Brito Guirardello, E., 2017. Nursing practice environment, job outcomes and safety climate: a structural equation modelling analysis. J. Nurs. Manag. 25 (1), 46–55. https://doi.org/10.1111/jonm.12427.

Ezejiofor, T.I.N., Ezejiofor, A.N., Orisakwe, O.E., Nwigwe, H.C., Osuala, F.O., Iwuala, M. O., 2014. Anicteric hepatoxicity: a potential health risk of occupational exposures in Nigerian petroleum oil refining and distribution industry. J. Occup. Med. Toxicol. 9 (1), 1–14. https://doi.org/10.1186/1745-6673-9-3.

Fornell, C., Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. J. Market. Res. 18 (1), 39–50. https://doi.org/10.1177/002224378101800104.

Hair, J.F., Sarstedt, M., Ringle, C.M., Mena, J.A., 2012. An assessment of the use of partial least squares structural equation modeling in marketing research. J. Acad. Market. Sci. 40 (3), 414–433. https://doi.org/10.1007/s11747-011-0261-6.

Hair, Joe F., Sarstedt, M., Hopkins, L., Kuppelwieser, V.G., 2014. Partial least squares structural equation modeling (PLS-SEM): an emerging tool in business research. Eur. Bus. Rev. 26 (2), 106–121. https://doi.org/10.1108/EBR-10-2013-0128.

Hair, Joseph F., Risher, J.J., Sarstedt, M., Ringle, C.M., 2019a. When to use and how to report the results of PLS-SEM. Eur. Bus. Rev. 31 (1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203.

Hair, Joseph F., Sarstedt, M., Ringle, C.M., 2019b. Rethinking some of the rethinking of partial least squares. Eur. J. Market. 53 (4), 566–584. https://doi.org/10.1108/EJM-10-2018-0665.

Hair, J.F., Howard, M.C., Nitzl, C., 2020. Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. J. Bus. Res. 109 (November 2019), 101–110. https://doi.org/10.1016/j.jbusres.2019.11.069.

Hamdollah, R., Baghaei, P., 2016. Partial least squares structural equation modeling with R. Practical Assess. Res. Eval. 21 (1), 1–16. https://doi.org/10.7275/d2fa-qv48.

Hamel, K., 2020. Avoid fatalities and injuries in the oil and gas industry. https://ohsonline.com/articles/2020/02/01/avoid-fatalities-and-injuries-in-the-oil-and-gas-industry.aspx.

Han, Y., Li, J., Cao, X., Jin, R., 2020. Structural equation modeling approach to studying the relationships among safety investment, construction employees' safety cognition, and behavioral performance. J. Construct. Eng. Manag. 146 (7), 04020065 https://doi.org/10.1061/(asce)co.1943-7862.0001858.

Hussein Ali, H., Mohd Said, R., Abdullah, A., Mat Daud, Z., 2017. The impact of organizational culture on corporate financial performance: a review. Intern. J. Eco., Com. Manage. 5 (8), 585–597. https://www.researchgate.net/publication/323990984_THE_IMPACT_OF_ORGANIZATIONAL_CULTURE_ON_CORPORATE_FINANCIAL_PERFORMANCE_A_REVIEW.

Ignacio, J.J., Malenab, R.A., Pausta, C.M., Beltran, A., Belo, L., Tanhueco, R.M., Promentilla, M.A., Orbecido, A., 2019. A perception study of an integrated water system project in a water scarce community in the Philippines. Water (Switzerland) 11 (8). https://doi.org/10.3390/w11081593.

International Labour Organization, 2017. Occupational Safety and Health in the Oil and Gas Industry in Selected Sub-saharan African Countries. https://www.ilo.org/sector/activities/sectoral-meetings/WCMS_554798/lang–en/index.htm.

Kaya, B., Abubakar, A.M., Behravesh, E., Yildiz, H., Mert, I.S., 2020. Antecedents of innovative performance: findings from PLS-SEM and fuzzy sets (fsQCA). J. Bus. Res. 114 (April), 278–289. https://doi.org/10.1016/j.jbusres.2020.04.016.

Kaynak, R., Tuygun Toklu, A., Elci, M., Tamer Toklu, I., 2016. Effects of occupational health and safety practices on organizational commitment, work alienation, and job performance: using the PLS-SEM approach. Int. J. Bus. Manag. 11 (5), 146. https://doi.org/10.5539/ijbm.v11n5p146.

Kim, T.K., 2015. T test as a parametric statistic. Kor. j. anesthesiol. 68 (6), 540–546. https://doi.org/10.4097/kjae.2015.68.6.540.

Kumar, D.S., Purani, K., 2018. Model specification issues in PLS-SEM: illustrating linear and non-linear models in hospitality services context. J. Hosp. Tour. Technol. 9 (3), 338–353. https://doi.org/10.1108/JHTT-09-2017-0105.

Lay, A.M., Saunders, R., Lifshen, M., Breslin, C., Lamontagne, A., Tompa, E., Smith, P., 2016. Individual, occupational, and workplace correlates of occupational health and safety vulnerability in a sample of Canadian workers. Am. J. Ind. Med. 59 (2), 119–128. https://doi.org/10.1002/ajim.22535.

Lee, J., Kim, M., 2021. Estimation of the number of working population at high-risk of COVID-19 infection in Korea. Epidemiol. Health 42, 1–11. https://doi.org/10.4178/epih.e2020051.

Leguina, A., 2015. A primer on partial least squares structural equation modeling (PLS-SEM). Int. J. Res. Method Educ. 38 (2), 220–221. https://doi.org/10.1080/1743727x.2015.1005806.

Machfudiyanto, R.A., Latief, Y., Yogiswara, Y., Setiawan, R.M.F., 2017. Structural equation model to investigate the dimensions influencing safety culture improvement in construction sector: a case in Indonesia. AIP Conf. Proc. https://doi.org/10.1063/1.4985489, 1855.

Min, J., Kim, Y., Lee, S., Jang, T.W., Kim, I., Song, J., 2019. The fourth industrial revolution and its impact on occupational health and safety, worker's compensation and labor conditions. Saf. Health at Work 10 (4), 400–408. https://doi.org/10.1016/j.shaw.2019.09.005.

Montallana, V.K.G., Soriano, C.B., Zamoranos, F.A.R., 2019. Developing a Safety Culture Model for the Philippine Oil and Gas Industry. Unpublished manuscript. Petroleum Engineering Department, Palawan State University.

Muspratt, A., 2019. Introduction to Oil and Gas Industry. https://www.oilandgasiq.com/strategy-management-and-information/articles/oil-gas-industry-an-introduction.

Nkrumah, E.N.K., Liu, S., Doe Fiergbor, D., Akoto, L.S., 2021. Improving the safety–performance nexus: a study on the moderating and mediating influence of work motivation in the causal link between occupational health and safety management (ohsm) practices and work performance in the oil and gas sector. Int. J. Environ. Res. Publ. Health 18 (10), 1–23. https://doi.org/10.3390/ijerph18105064.

Palese, A., Grassetti, L., Bressan, V., et al., 2019. A path analysis on the direct and indirect effects of the unit environment on eating dependence among cognitively impaired nursing home residents. BMC Health Serv. Res. 19, 775. https://doi.org/10.1186/s12913-019-4667-z, 2019.

Park, J., Park, J.S., Han, B., Kim, Y., 2017. Vulnerability of employees in businesses with fewer than five workers (micro-enterprises) to occupational safety and health problems. Am. J. Ind. Med. 60 (12), 1056–1065. https://doi.org/10.1002/ajim.22783.

Phillips, E.K., Conaway, M.R., Jagger, J.C., 2020. Percutaneous injuries before and after the needlestick safety and prevention Act. N. Engl. J. Med. 366 (7), 670–671. https://doi.org/10.1056/nejmc1110979.

Premji, S., Smith, P.M., 2013. Education-to-job mismatch and the risk of work injury. Inj. Prev. 19 (2), 106–111. https://doi.org/10.1136/injuryprev-2011-040314.

Rigdon, E.E., 2014. Rethinking partial least squares path modeling: breaking chains and forging ahead. Long. Range Plan. 47 (3), 161–167. https://doi.org/10.1016/j.lrp.2014.02.003.

Ringle, C.M., Wende, S., Will, A., 2005. Smart PLS 2.0 M3. Hamburg University of Hamburg. www.smartpls.de.

Rupakheti, D., Singh Pradhan, P.M., Basel, P., 2018. Occupational safety and health vulnerability among brick factory workers in Dhading district, Nepal. Ann. Glob. Health 84 (3), 481–487. https://doi.org/10.29024/aogh.2313.

Sabri, A., Wan Mohamad Asyraf, W.A., 2014. The importance-performance matrix analysis in partial least square structural equation modeling (PLS-SEM). Int. J. Math. Res. 3 (1), 1–14. https://doi.org/10.18488/journal.24/2014.3.1/24.1.1.14.

Sarstedt, M., Cheah, J.H., 2019. Partial least squares structural equation modeling using SmartPLS: a software review. J. Market. Anal. 7 (3), 196–202. https://doi.org/10.1057/s41270-019-00058-3.

Sarstedt, M., Ringle, C.M., Smith, D., Reams, R., Hair, J.F., 2014. Partial least squares structural equation modeling (PLS-SEM): a useful tool for family business researchers. J. Fam. Bus. Strat. 5 (1), 105–115. https://doi.org/10.1016/j.jfbs.2014.01.002.

Ministry of Labour, Training and Skills Development, 2013. The Occupational Health and Safety Awareness and Training Regulation: Supporting Healthy and Safe Workplaces. https://www.labour.gov.on.ca/english/hs/sawo/pubs/fs_trainingreg.php.

Smith, P.M., Oudyk, J., Potter, G., Mustard, C., 2020. Labour market attachment, workplace infection control procedures and mental health: a cross-sectional survey of Canadian non-healthcare workers during the COVID-19 pandemic. Ann. Work Exp. Health 1–11. https://doi.org/10.1093/annweh/wxaa119.

Smith, P.M., Oudyk, J., Potter, G., Mustard, C., 2021. The Association between the Perceived Adequacy of Workplace Infection Control Procedures and Personal Protective Equipment with Mental Health Symptoms: a Cross-sectional Survey of Canadian Health-care Workers during the COVID-19 Pandemic: L'association en. Can. J. Psychiatr. 66 (1), 17–24. https://doi.org/10.1177/0706743720961729.

Sohaib, O., Hussain, W., Asif, M., Ahmad, M., Mazzara, M., 2020. A PLS-SEM neural network approach for understanding cryptocurrency adoption. IEEE Acc. 8, 13138–13150. https://doi.org/10.1109/ACCESS.2019.2960083.

Stillman, A., 2020. Covid-19 Is Killing Oil Workers at an Unparalleled Pace in Mexico. https://www.bloomberg.com/news/articles/2020-07-15/covid-19-is-killing-oil-workers-at-unparalleled-pace-in-mexico.

Sullivan, G.M., Feinn, R., 2012. Using effect size-or why the P value is not enough. J. grad. med. educ. 4 (3), 279–282. https://doi.org/10.4300/JGME-D-12-00156.1.

Sun, L., Ji, S., Ye, J., 2018. Partial least squares. In: Multi-Label Dimensionality Reduction. https://doi.org/10.1201/b16017-6.

Walensky, R.P., Del Rio, C., 2020. From mitigation to containment of the COVID-19 pandemic: putting the SARS-CoV-2 genie back in the bottle. JAMA - J. Am. Med. Ass. 323 (Issue 19), 1889. https://doi.org/10.1001/jama.2020.6572, 1890.

WHO, 2017. Occupational Health. https://www.who.int/health-topics/occupational-health.

Wong, K.K.K., 2013. Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. Market. Bull. 24 (1), 1–32. https://www.researchgate.net/file.PostFileLoader.html?id=55d6fbae5dbbbdb3608b45e0&assetKey=AS%3A273837248188417%401442299297149.

World Health Organization, 2021. COVID-19: Occupational Health and Safety for Health Workers: Interim Guidance, 2 February 2021. https://www.who.int/publications/i/item/WHO-2019-nCoV-HCW_advice-2021.1.

Wu, C., Song, X., Wang, T., Fang, D., 2015. Core dimensions of the construction safety climate for a standardized safety-climate measurement. J. Construct. Eng. Manag. 141 (8), 04015018 https://doi.org/10.1061/(asce)co.1943-7862.0000996.

Yanar, B., Kosny, A., Smith, P.M., 2018. Occupational health and safety vulnerability of recent immigrants and refugees. Int. J. Environ. Res. Publ. Health 15 (9). https://doi.org/10.3390/ijerph15092004.

Yanar, B., Lay, M., Smith, P.M., 2019. The interplay between supervisor safety support and occupational health and safety vulnerability on work injury. Saf. Health at Work 10 (2), 172–179. https://doi.org/10.1016/j.shaw.2018.11.001.